COMMITTEE ACTIVITIES

Scientific and Public Issues Committee Position Statement: RADIATION STANDARDS FOR SITE CLEANUP AND RESTORATION

Ronald Kathren, Francis Massé, Kenneth Mossman, Genevieve Roessler, Keith Schiager

Executive Summary

The Health Physics Society* welcomes this opportunity to participate in the enhanced rulemaking process initiated by the Nuclear Regulatory Commission (NRC) for development of standards for site cleanup and restoration of decommissioned nuclear facilities. This participatory process is particularly important because of the tremendous impact these standards will have on this nation's economy for many years. We encourage regulatory agencies to establish radiation protection standards that are consistent with the recommendations of the scientific advisory organizations established specifically to make recommendations in this area.

Radiation protection standards should be based on health risks; they should be clearly related to quantities that can be measured, such as radiation exposure rates or radioactivity concentrations in soil, or on equipment or buildings. To ensure optimum protection of public health and environmental values, standards for site cleanup and restoration should be consistent with the fundamental principles recommended for all radiation protection activities, i.e. that **radiation doses should be kept as low as reasonably achievable (ALARA), taking into account economic and social factors, with an upper limit to the dose that is likely to be received by any individual.** The "economic and social factors" that should be taken into account include the health and environmental risks introduced by cleanup activities, e.g. the use of chemicals, construction activities, transportation, waste processing and disposal, as well as the direct financial costs.

We recognize and sympathize with the sincere apprehension many people have about health risks imposed by radiation exposures. This is also our primary concern, since our profession is dedicated to the prevention of unwarranted health risk due to radiation. We have no magic formula for allaying the fears of radiation, but we offer basic principles of protection, developed over several decades, that are appropriate for radiation and most other environmental hazards. Based on these principles, we provide several specific recommendations, followed by a discussion of the general considerations on which they are founded. Finally, we include comments on the four kinds of objectives described by the NRC in its paper "Issues for Discussion at Workshops" (1993).

SPECIFIC RECOMMENDATIONS

1. **Remedial action should do more good than harm; the standards for site cleanup and restoration should be based on the principle of balancing the societal costs and risks of the cleanup against the societal benefits of actual radiological risk reduction, to assure that the net benefit to society is maximized.** Nonradiological risks, e.g., the use of chemicals for decontamination and the mechanical hazards of demolition and transportation activities, should be evaluated to assure that decisions are based on minimizing the total detriment, not just the radiological risk. The amounts spent specifically to achieve health benefits should be in the same range as is acceptable for any other health protection program that is undertaken voluntarily by the public. Expenditures for other categories of benefits, e.g., aesthetics, public good will, property valuation, etc., should be separately identified and justified.
2. **For decisions on decommissioning strategies, the ALARA principle should be applied to the total radiation dose to society, including workers at the site as well as the general public.** The standards must recognize the fact that the dose to site workers is part of the total dose to society and must be included in the balancing of risks and benefits. This requirement is specifically addressed by the ICRP, as follows: "The need for and extent of remedial action has to be judged by comparing the benefit of the reductions in dose with the detriment of the remedial work, including that due to doses incurred in the remedial work." (ICRP, 1991, ¶219) This recommendation is particularly relevant to decisions regarding immediate vs. deferred decommissioning, allowing for radioactive decay before final cleanup and restoration to a condition suitable for unrestricted use.
3. **For unrestricted use of a restored site, we endorse the limit of 100 mrem (1 mSv) total effective dose equivalent (TEDE) to any member of the public in any one year from all nonmedical, manmade sources combined, recommended by both the ICRP (1991) and the NCRP (1993).** For purposes of these recommendations, we use the term "total effective dose equivalent" (TEDE) adopted by the NRC (1991), which is the same quantity as the "effective dose" defined by the NCRP (1993); it is the sum over all tissues of the committed dose equivalent from penetrating external

[continued]

radiation and from intakes of radioactive materials. For site cleanup and restoration standards, we recommend that the dose limit be applied to all site-specific, nonoccupational sources, except indoor radon, including natural radionuclides whose concentrations have been enhanced by human activities.

4. **We recommend that a compliance screening level of 25 mrem be applied to the mean annual TEDE to the critical population group, defined as the most highly exposed homogeneous group affected by the restored site.** If the mean annual TEDE to the critical group is likely to exceed 25 mrem, an evaluation should be made to ensure that no individual is likely to receive an annual TEDE exceeding 100 mrem (1 mSv) from all site-specific, nonoccupational sources, excluding indoor radon.
5. **Standards for site cleanup and restoration should include an assessment screening level below which further dose assessment is not required.** The selection of this screening level is more a matter of practicality than of explicit risk assessment. For all site-specific, nonoccupational sources of radiation exposure, excluding indoor radon, we recommend an assessment screening level of 5 mrem annual mean TEDE to the critical group. We consider 5 mrem per year to be an appropriate screening level because it is unlikely that efforts to reduce doses below that level will do more good than harm.
6. **For unrestricted release of sites containing ^{226}Ra, ^{232}Th or ^{228}Ra, we recommend a soil concentration limit of 5 pCi/g above the normal concentration for the region to prevent excessive ^{222}Rn or ^{220}Rn concentrations in indoor air.** To limit the potential source for indoor radon adequately, the concentration should be averaged over an area of no less than 25 m^2 and no more than 100 m^2 and a soil depth of no less than 0.5 m and no more than 1 m. As a screening level for soil containing ^{226}Ra, ^{232}Th or ^{228}Ra, we recommend a soil concentration of 1 pCi/g above the normal concentration for the region, averaged over the same area and depth.
7. **Standards for site cleanup and restoration should be based on probabilistic risk assessments designed to provide the best estimates of the <u>distributions and uncertainties</u> of doses that are likely to be received after restoration through the use of state-of-the-art, peer-reviewed and thoroughly documented calculational models and computer codes.** The distribution of doses to the members of the public during and following decommissioning will be entirely different from the dose distributions resulting from operational emissions, which are limited by NRC and EPA regulations. During plant operation, most of the dose to the general public is rather uniformly distributed to relatively large numbers of the adjacent population. After decommissioning there will be essentially no dose to the population adjacent to the site. Only a very small segment of the population who reside or work on the restored site will receive any "public" dose. The hypothetical concept of a single "maximally exposed individual", for whom all exposure variables are assumed to be maximized simultaneously, should be replaced by calculations of the mean TEDE to the critical group, i.e., the homogeneous group receiving the highest doses from the restored site. Although modelling is required for calculating doses to critical groups and individuals, the input data to the models should be measurable, verifiable quantities, such as exposure rates or concentrations of radionuclides in environmental media.

GENERAL CONSIDERATIONS

Basis for Standards

Concern for environmental quality is justified by many considerations, including aesthetic values, maintaining ecological balance, conservation of resources and protection of human health. Of these diverse considerations, only the protection of human health requires radiological standards for decontamination or restoration. Since radiation cannot be seen, heard, felt or tasted, it cannot, of itself, produce any aesthetic degradation. For levels of environmental radiation or radioactivity that are within established standards for protection of human health, there is no anticipated adverse effect on ecological systems. Criteria for conservation of minerals, water or other natural resources are based on the preservation of a balanced ecosystem and on potential future use by humans, and only the health aspects of potential future use by humans is dependent on radiological standards. Consequently, there is no aesthetic, ecological or conservation basis for radiation protection standards different from those required to protect human health, and the economic and social factors that must be taken into account are comparable to those involved in any other health issue for which benefits are weighed against costs.

We concur with the recommendations of the ICRP (1991, ¶113) regarding criteria for intervention in existing situations:

"(a) The proposed intervention should do more good than harm, i.e., the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including social costs, of the intervention.

(b) The form, scale, and duration of the intervention should be optimized so that the net benefit of the reduction of dose, i.e., the benefit of the reduction in radiation detriment, less the detriment associated with the intervention, should be maximized."

We also subscribe to the ICRP recommendation that "the sum of the effective doses from each type of exposure"

[continued]

(i.e., occupational and public) "from a given source should be used in the optimisation procedures." (ICRP, 1991, ¶208)

Risk Assessment

Although it is possible to measure small radiation exposures and quantities of radioactivity, it is not possible to detect or measure the risk they are presumed to produce. Realistic assessment of the potential risk from residual radioactivity requires objective evaluation of the environmental transport of radionuclides and the potential for human exposure. The risk to society is calculated as the sum of the risks to its individual members and the TEDE is the quantity that best represents the biological risk to an individual from radiation exposure.

The collective societal dose, which is the sum of the TEDEs to all members of the public and to all workers, is an acceptable surrogate for the societal radiological risk and may be used in calculations for optimization when the collective dose is known. However, it must be recognized that the collective societal dose depends as much on demographics as it does on dosimetry. If the size and characteristics of the exposed population are unknown, there can be no valid estimate of societal dose. **For site cleanup and restoration involving radionuclides that will exist for many decades or centuries, societal dose cannot be used as a surrogate for risk.**

Almost all radiation risk coefficients originate as relative risks, i.e., the ratio of the observed to the expected number of cases in an exposed population. For most of the biological effects of radiation exposure, the relative risk model provides a somewhat better fit to the data than does the absolute risk model. If the only parameter that changes the societal dose is the size of the population, the average individual dose is the preferred measure of societal risk, since the societal relative risk is exactly equal to the average individual relative risk. Also, the upper limit to the societal relative risk is appropriately represented by the mean relative risk to the critical group. For this reason, **we recommend that radiological standards for completion of site cleanup and restoration be expressed only as an individual dose limit, evaluated in terms of the mean annual TEDE to the critical group.**

If a dose is determined only by calculation, the principal input data should be quantities that are measurable and the model used for the calculation should be demonstrably reliable. Models for environmental transport and human or ecological exposures should be state-of-the-art, peer-reviewed and thoroughly documented. The modeling results should provide the best estimates of the distributions, including the uncertainties, of doses likely to be received by various population groups. The hypothetical concept of a single "maximally exposed individual," for whom all exposure variables are assumed to be maximized simultaneously, should be replaced by a calculation of the mean annual TEDE to a defined critical group.

Risk Management

Risk management decisions by regulatory agencies as well as by the affected licensees should be designed to maximize the benefit to the public. When applying the ALARA principle to doses below the mandatory individual dose limit, additional remedial actions should be justified by the likelihood for cost-effective risk avoidance on a case-by-case basis, not by setting a lower, arbitrary, regulatory dose limit. Expenditures of public funds should be justified by, and proportionate to, the societal risk that will be avoided by the proposed action. We do not believe that it is in the public interest to spend large amounts of public funds for remediation of a calculated public health detriment that is too small to be observed.

We recognize that there are societal benefits other than health that may be attained by site cleanup and restoration, e.g., property valuation and tax revenues, resource conservation, public acceptance, etc., and recommend that each of these be evaluated utilizing benefit/cost ratios that are considered acceptable for achieving similar public benefits in other situations. As health professionals, however, we offer recommendations only on remedial actions to obtain benefits that are health related. To the extent that site cleanup is expected to be justified by health benefits, we believe that it is appropriate to compare the anticipated results with the societal health benefits attainable by expenditures of resources in other ways, e.g., construction of hospitals, education of medical personnel, immunization of children, etc.

REVIEW OF ALTERNATIVES PROPOSED BY THE NRC

Several basic kinds of objectives or approaches have been suggested as the basis for radiological criteria for decommissioning (NRC, 1993). Each of the suggested objectives are discussed below, with recommendations for modifications or alternatives.

Risk Limit

Limitation of the risk to any individual is one of the essential components of radiological standards for site cleanup and restoration. For risks from radiation, we believe the limit should not be expressed as a risk value, but as an upper limit to the annual TEDE that is likely to be received by an individual at a restored site. We concur with the dose limit for individual members of the general public recommended by both the ICRP (1991) and the NCRP (1993) of 100 mrem TEDE in any year from all nonoccupational, nonmedical, manmade or site-specific sources combined, excluding indoor radon. We believe that compliance with this limit can best be demonstrated through the application of a compliance screening level of 25 mrem mean annual TEDE to the critical group. If this value is exceeded, an evaluation must be made to ensure that no individual is likely to receive a dose exceeding the individual dose limit.

[continued]

Risk Goal

We do not recommend the establishment of a standard that would define a level of residual risk to the public deemed trivial in all cases as the primary objective of decommissioning efforts. Our objection to this approach is twofold: First, there is no universally acceptable definition of trivial risk; even extremely small risks are considered by some people to be unacceptable if they perceive no personal benefit in taking the risk or if they believe the reason for taking the risk is immoral or unacceptable. Second, this approach would allow no balancing of societal benefits against societal costs of decommissioning, a fundamental principle of public health and radiation protection.

As a practical measure, we believe that the standards should include a lower limit for action. The ALARA principle implies that not only the management of risk, but also the assessment of risk, should be optimized. The effort expended in assessing a risk should not be disproportionate to the risk itself. If the ALARA principle could be applied quantitatively to all cases, the lower limit for action would be the point where the cost of a realistic risk assessment would exceed the potential benefit of any cleanup. For practical applications, however, a screening mechanism is needed to determine whether the potential benefit of decontamination or restoration is likely to justify a detailed risk assessment. We believe that a calculated mean TEDE of 5 mrem above normal background to the critical group in any one year would be appropriate as a screening level to determine whether any further assessment is likely to be beneficial and, therefore, necessary.

Best Available Technology

We recommend the use of best available technology (BAT) whenever it is compatible with the goal of optimizing total benefits. We do not believe that BAT should be the only criterion for site cleanup, regardless of cost or effectiveness, because inordinate expenditures could be required with little or no benefit. If this objective were to be used without other restrictions, it would imply that a site could be released for unrestricted use regardless of the remaining radioactivity or risk as long as the BAT had been used. We would certainly object to this implication on the basis that alternatives to unrestricted release should be considered if there was a significant residual risk after the application of the best available technology.

Return to Natural Background Levels

We do not consider the return to natural background levels to be ethically or scientifically justified as a primary objective for site cleanup and restoration. This approach is ethically unjustified since it involves no consideration of actual risk nor of cost. Furthermore, there is no scientific justification for such a standard since both "manmade" and "natural" radionuclides impose the same kind of risks.

Some proposed environmental restoration projects involve sites contaminated with small amounts of "manmade" radioactivity in soil that are to be returned to their "natural" state. The concept of "natural" should not be arbitrarily restricted to mean that only the original nuclides and concentrations are present. We are not so naive to believe that digging up some soil, burying it in containers in another location, and replacing it with soil from a third location is more "natural" than leaving small amounts of radioactivity in place! The important consideration should be the quantities and distributions of all radionuclides in the contaminated materials and the potential exposures to humans. Conditions that produce a distribution of radiation doses and risks to people within the normal range of natural background should be regarded as "natural."

The distribution and variability of radioactivity in the environment, and dose rates from natural sources, provides an excellent framework for establishing criteria for site cleanup and restoration. The recommended individual dose limit and the two recommended screening levels refer to doses in addition to the dose from natural background. The recommended compliance screening level of 25 mrem in any year is of approximately the same magnitude as the geographic variability of doses from natural background; it is comparable to the difference in annual dose likely to be experienced by a person who moves from one location to another. The recommended assessment screening level of 5 mrem in any year is approximately the same magnitude as the temporal variability of the dose from natural background at a single location; it is the difference in annual dose anyone is likely to experience without changing location. If the true background dose rate for the site was never established, the average background for the region should be used for comparison. However, it is immaterial whether any additional dose rate above the average background is contributed by natural or manmade radionuclides.

* The Health Physics Society, formed in 1956, is a scientific organization concerned with the protection of people and the environment from radiation. Today its membership numbers more than 6,400 and includes professionals representing all scientific and technical areas related to radiation protection drawn from academia, government, medical institutions, research laboratories and industry from 50 states, the District of Columbia, and Puerto Rico. The Society has more than 350 members in nearly 50 foreign countries. The Society is chartered in the United States as a nonprofit scientific organization, and as such is not affiliated with any governmental or industrial organization.

References

International Commission on Radiological Protection (1991). *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Pub. 60, Pergamon Press, New York.

National Council on Radiation Protection and Measurements (1993). *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, NCRP Publications, Bethesda, Maryland.

Nuclear Regulatory Commission (1991), "Standards for Protection Against Radiation; Final Rule", 56FR23360-23474 21 May 1991.

Nuclear Regulatory Commission (1993), "Proposed Rulemaking to Establish Radiological Criteria for Decommissioning - Issues for Discussion at Workshops" (unpublished). ■